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NOTES

Observations on the Pollination Biology and Flowering Phenology of Texan *Matelea reticulata* (Engelm. Ex A. Gray) Woods. (Asclepiadaceae).

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Although the pollination mechanisms of Asclepiadaceae have received considerable attention, the majority of research has focused on the genus *Asclepias* (e.g., Kephart, American Journal of Botany 68(2): 226–232, 1981; Willson et al., American Midland Naturalist 102:23–32, 1979; Willson and Price, Evolution 31:495–511, 1977; Willson and Rathke, American Midland Naturalist 92:47–57, 1974). As Liede (Madroño 41(4):266–276, 1994) points out, relatively few pollination observations have been made on other taxa and the majority of these have focused on Old World species (see also ASCLEPOL: http://www.uni-bayreuth.de/departments/planta2/research/Pollina /as_pol_d.htm). Only three studies of New World taxa besides *Asclepias* are known (e.g., *Fischeria*: Skutch, Brenesia 30:13–20, 1988; *Funastrum*: Kunze and Liede, Systematics and Evolution 178:95–105, 1991; *Matelea*: Liede, Madroño 41(4): 266–276, 1994) and none of Texan populations. In order to increase our depauperate understanding of Texan vining asclepiads, this study sought to: (1) identify the floral visitors of Texan *Matelea reticulata*, (2) track the vines' flowering phenology, and (3) analyze visitor activity based on pollinarium removal rates and pollinium insertion rates. The species was chosen due to its natural occurrence on our Garden grounds and to allow comparison with previously studied Mexican populations by Liede (Madroño 41(4):266–276, 1994).

A naturally occurring population of *Matelea reticulata* was studied in a *Quercus virginiana-Juniperus ashei* dominated forest patch on the grounds of Zilker Botanical Garden, Austin, Texas from 20 July–5 Aug 1999. The vines grew to 6 m into the canopy of a *Juniperus ashei* tree. On 20 July, inflorescences of the intertwining vines were labeled with small, cardboard labels. On 22 July 1999, insect visitors were observed from 09:30–12:00 and 14:00–16:30. Visitors were caught in a small, cylindric plastic container and killed by exposure to ethyl alcohol. The container could comfortably be held in one hand (5 cm diam. × 2.5 cm deep) and proved a more effective capturing device in the crowded canopy than standard insect nets. At least one representative of all visiting species was captured. Following the five hours of visitor observation, all open and senesced flowers of the tagged inflorescences were collected in a baseline harvest and preserved in 70% ethyl alcohol. These flowers were then analyzed under the microscope for pollinarium removal and pollinium insertion. From 23 July–5 Aug, newly opened flowers on the tagged inflorescences were marked on the abaxial petal surface with colored, water-resistant ink on a daily basis (between 15:00 and 17:30). A different color ink was used each day to allow tracking of flower longevity. Previously marked, senesced flowers were collected as newly opened flowers were marked. All collected senesced flowers were analyzed under a microscope for pollinarium removal and pollinium insertion. Captured insects were identified by the author and deposited at Zilker Botanical Garden.

Insect activity was sparse. Within a five hour observation period, only thirty-four floral visitation events occurred. However, the number of insect taxa and visitation events is potentially underestimated as the observation period did not extend to dawn or dusk and the capturing of insects may have interfered with visitation frequency. Nonetheless, separate anecdotal observations at least support a relative low frequency of visitation in the absence of capturing activity.

Visitors were flies, except for one wasp in the Chalcidoidea. The wasp was a frequent, active visitor, landing on the broad petals and moving toward the base of the staminal column to partake of the nectar. Minute in size, 1 mm or less, the wasp is not much bigger than a pollinium and thus unlikely powerful enough to dislodge an entire pollinarium. It was never observed near the upper portions of the staminal column where the corpuscula are displayed.

The fly visitors belonged to three families: Drosophilidae, Lonchaeideae, and Sarcophagidae. Pollinaria were found exclusively on the labella of the haustellum of the Sarcophagids. No pollinaria were found on flies in the other families—due to their small size (<3 mm), it is unlikely that they are active pollinators of *M. reticulata*. Only flies (Calliphoridae, Muscidae, and Tachinidae) were found visiting a Mexican population of *M. reticulata* (Liede, Madroño 41(4):266–276, 1994).

In contrast to the Mexican population of *M. reticulata* studied by Liede (Madroño 41(4):266–276, 1994), which bore inflorescences displaying no more than six open flowers simultaneously, vines of the present study bore inflorescences displaying no more than three open flowers simultaneously. In addition, a strong musky fragrance was detected throughout the study period at various times of day. No fragrance was detected in the population studied by Liede (Madroño 41(4):266–276, 1994).

The total number of open flowers reached a peak on 25 July with 48 open flowers and declined steadily thereafter (Fig. 1). Clearly the study period

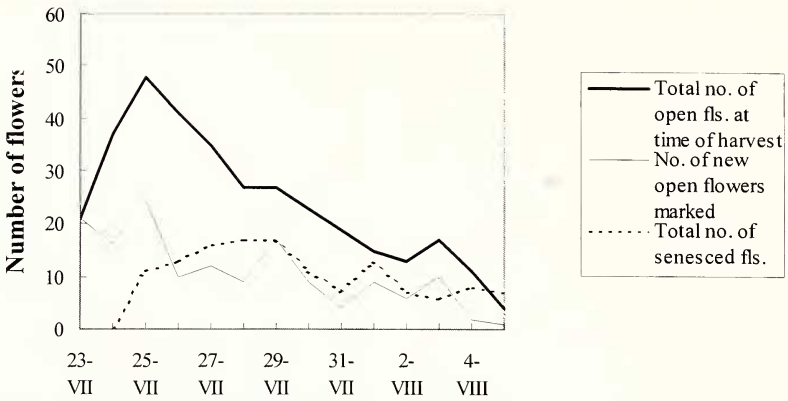

FIG. 1. Number of newly opened flowers, senesced flowers, and total open flowers per day of a Texan population of *Matelea reticulata* from 23 Jul–5 Aug 1999.

coincided partly with the end of the flowering of the population. By 9 Aug, no open flowers were displayed as all inflorescences (including the non-tagged) had senesced.

Floral longevity was short, as 43.84% of all flowers marked over the period from 23 July–4 Aug senesced after two days. Flowers senescing within two and three days account for 72.61% of all flowers. Almost nine percent of flowers were unaccounted for and probably eaten by Tussock moth caterpillars (Arctiidae) which were removed from the vines whenever detected.

The sparse insect activity was reflected in pollinarium removal rates. The average number of pollinaria removed per flower on the baseline flower harvest date of 22 July was 0.54 (Fig. 2A). The average number of pollinaria removed per flower in *M. reticulata* decreased over the study period from this baseline harvest high (Fig. 2A).

As found by Liede for Mexican *Matelea reticulata* (Madroño 41(4):266–276, 1994), and in contrast to studies on N. American *Asclepias* (e.g., Chaplin and Walker, Ecology 63:1857–1870, 1982; Willson and Rathke, American Midland Naturalist 92:47–57, 1974) pollinarium removal did not increase with umbel size ($r = -0.16$, $t = -2.59$, $P > 0.08$). Twice as many flowers had only one pollinarium removed (27.85%) as those that had two removed (12.66%). No flowers in any inflorescence size class had three or more pollinaria removed (Table 1). There was no significant difference between Liede (Madroño 41(4):266–276, 1994) and the present study in the number of flowers in all inflorescence size classes with one or two pollinaria removed ($P = 0.429$).

Figure 2B depicts the daily percentage of senesced flowers with removed pollinaria. The mean daily percentage of flowers in this class over the period from 25 July–1 Aug is 26.89% (SD = 13.50). In only one of the eight flowers not senescing until four days, had pollinaria been removed. Although over 1.5 times as many flowers senesced after two days than after three days, there is no significant difference in pollinarium removal rates between flowers in these senescence classes over the period of the study ($F_{0.95_{1,22}} = 0.02 < 4.30$, $P = 0.88$).

Not surprisingly based on the sparse insect visitation, pollinium insertion rates were also quite low (Fig. 2C). The peak daily pollinium insertion rate of 0.24 was achieved on 28 July. No inserted pollinia were detected in senesced flowers in eight of the fifteen days of study.

The average pollinarium removal rate from the baseline flower harvest of 0.54 pollinaria removed/flower (Figure 2A) is remarkably low compared to the previously reported 0.94 pollinaria removed/flower for Mexican *Matelea reticulata* (Liede, Madroño 41(4):266–276, 1994). Removal rates for other New World Asclepiads are considerably higher (e.g., Mexican *Funastrum* had 2.5 pollinaria removed/flower (Kunze and Liede, Systematics and Evolution 178:95–105, 1991) and N. American *Asclepias* had 3.6 pollinaria removed/flower (Lynch, Madroño 24:159–177, 1977). Weather could be a factor in the low pollinarium removal rates, but there is relatively little variability in Austin's climate in the summer months to drastically affect insect behavior. Although insect observation occurred a day after brief, scattered showers, temperatures quickly warmed to above 35°C and the day continued, as previous and subsequent days, to be characterized by sunny skies with occasional, scattered clouds. Perhaps, the annual drought conditions experienced from the end of June through the start of August could be a factor.

Another potential factor in the pollinarium removal rate could be proximity to edge. The population studied by Liede (Madroño 41(4):266–276, 1994) occurred entirely in open habitat, whereas the vines of the present study grew in a forest patch at least 5–7 m from any edge.

Proximity to edge could influence the visibility of flowers and thus potentially affect pollinator activity. Some flies, however, have been found to re-

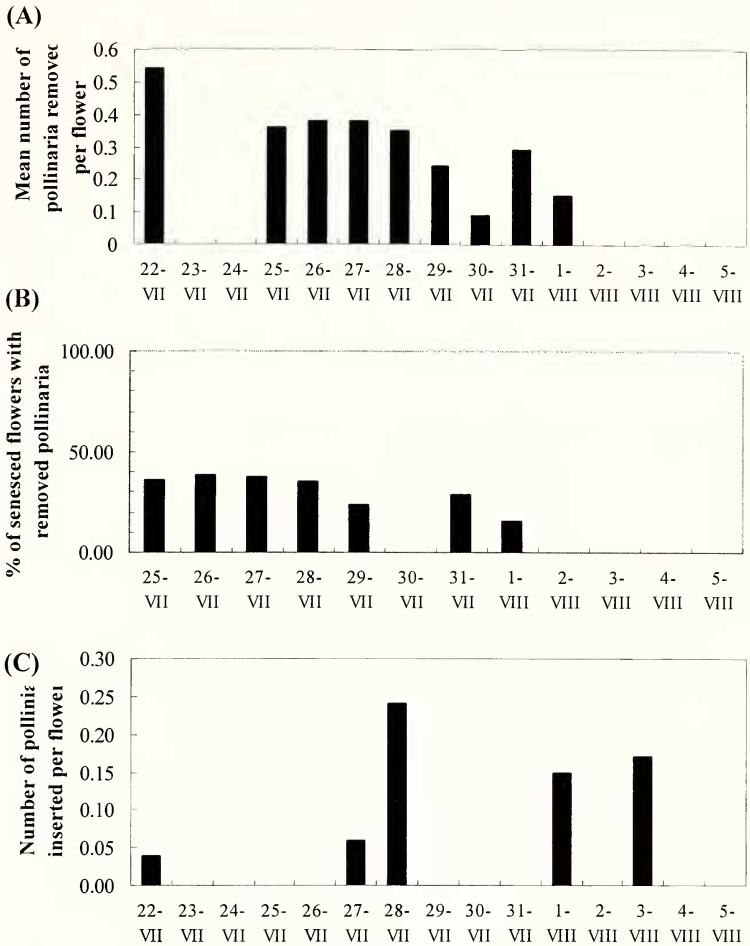

FIG. 2. (A) Pollinarium removal from flowers of *Matelea reticulata* over the period 22 July–5 Aug 1999. Both senesced and open flowers were analyzed from the baseline harvest of July 22. Subsequently only senesced flowers were analyzed. On July 23–24, no flowers had yet senesced, so none were analyzed. (B) Percent of senesced flowers with removed pollinaria (poll.) out of total number of senesced flowers over the period of 25 July–5 Aug 1999. (C) Pollinium insertion rates in *Matelea reticulata* from 22 July–5 Aug 1999. Both open and senesced flowers are included in the analysis for the baseline harvest 22 July. Only senesced flowers are analyzed from 23 July–5 Aug. No flowers senesced on 23 or 24 July.

spond more to olfactory than visual cues (Roy and Raguso, Oecologia 109:414–426, 1997). Interestingly, the scentless, highly visible Mexican population seems to have had higher pollinator visitation rates then the scented, "obscured" Texan population (or, perhaps, simply more effective pollinators?).

In addition, populations growing in full sunlight may produce more flowers (and thus potentially increase pollinator attraction) than shade-grown populations. Liede (Madroño 41(4):266–276, 1994) found an average of 2.24 flowers per inflorescence in Mexican *M. reticulata*, whereas the present study only found an average of 1.41 flowers per inflorescence in Texan *M. reticulata*.

To what extent the brief lifespan of individual flowers (72.61% senesced within 2–3 days) plays a role in pollinarium removal rates, also remains unclear. Unfortunately, no comparable flower longevity data could be found. Floral maintenance costs associated with water loss through floral transpiration and/or nectar production can be substantial (Ashman and Schoen, Nature 371:788–791, 1994; Nobel, Botanical Gazette 138:1–6, 1977) and could account for the brief flower lifespans. Certainly a longer lifespan would seem to increase the probability of insect visitation and thus pollinarium removal and pollinium insertion. A long flowering period would likewise increase the probability of insect visitation by lessening the effects of brief unfavorable conditions for pollinators (Willson and Rathke, American Midland Naturalist 92:47–57, 1974) and could thus potentially compensate for reduced individual flower longevity. Populations of this species generally flower from April through October (Correll and Johnston, Manual of the Vas-

TABLE 1. NUMBER OF FLOWERS OF *MATELEA RETICULATA* REMOVED ON 22 JULY 1999, IN FOUR INFLORESCENCE SIZE AND SIX POLLINARIUM (POLL.) REMOVAL CLASSES. Numbers in parentheses reported by Liede (1994). Numbers given for total pollinaria, pollinaria removed/inflorescence, and pollinaria removed/flower in the smallest inflorescence size class, have been corrected for the minor miscalculations in Liede (1994).

	Flowers/inflorescence								
	1		2		3		>3		No. of Flowers
No. of infl.	26	(11)	25	(39)	1	(17)	0	(5)	
Total flowers	26	(11)	50	(78)	3	(51)	0	(21)	79 (161)
Rem. poll./fl.									
0	15	(4)	31	(34)	1	(21)	0	(8)	47
1	9	(3)	13	(25)	0	(17)	0	(9)	22
2	2	(1)	6	(13)	2	(10)	0	(3)	10
3	0	(2)	0	(4)	0	(2)	0	(1)	0
4	0	(2)	0	(2)	0	(1)	0	(0)	0
5	0	(0)	0	(0)	0	(0)	0	(0)	0
Total poll.	13	(19)	25	(71)	4	(47)	0	(18)	
poll./infl.	0.50	(1.7)	1.00	(1.8)	4.00	(2.8)	0.00	(3.6)	
poll./fl.	0.50	(1.7)	0.50	(0.91)	1.33	(0.92)	0.00	(0.85)	

cular Plants of Texas, University of Texas Press, Dallas, 1979), but it remains unknown whether individual vines flower continuously for such a long period.

Although contrary evidence has been reported for *Asclepias* (Willson and Rathke, American Midland Naturalist 92:47–57, 1974), no support was found in either the present study or by Liede (Madroño 41(4):266–276, 1994) that pollinarium removal increases significantly with increasing inflorescence size in *Matelea reticulata* (Table 1). However, beyond concerns of potentially generally low visitation rates and very small inflorescence sizes (compared to *Asclepias*), a greater problem exists in that the investigative method may not be optimal for addressing such an issue. Data maybe skewed because the size of the inflorescence during the flower harvest may not accurately reflect its previous size—an obvious potential influence of pollinator activity. What if, for instance, a freshly opened and a senesced flower are collected from a two-flowered inflorescence. For the duration of its life, the senesced flower was the only open flower on the inflorescence. The freshly opened flower could have just opened that morning (before the harvest). For the duration of its brief life, it was the only open flower on the inflorescence. However, when harvested by the researcher, both will be considered belonging to the two-flower size inflorescence, eventhough at no point were two open flowers presented to visitors simultaneously. Although flower expansion was not observed on an hourly basis, the daily tracking of individual flowers in the present study supports the existence of such scenarios. The results of Liede (Madroño 41(4):266–276, 1994) and the present study, with regard to increased pollinarium removal with increased inflorescence size, are thus poor evidence for resolving the issue. It is recommended that future studies on the influence of inflorescence size be conducted through a more controlled experimental approach.